7. Preliminary Note on New Determinations of the Electric Resistance of Liquids. By W. Peddie, B.Sc.

(*Abstract.*)

In this paper Mr Peddie described some preliminary experiments made on the resistance of dilute solutions of sulphuric acid (ordinary commercial). The solution is enclosed in a glass tube, which passes through a metal vessel containing water. Each end of the tube dips into a separate vessel containing some of the acid solution, and a platinum electrode is placed in each vessel. This apparatus is joined in circuit with a Helmholtz tangent galvanometer and a Brush dynamo. The current from the dynamo is then passed through the arrangement, and the water surrounding the tube is stirred constantly until its temperature ceases to rise. The temperature of the water, the temperature of the air, and the current strength are then noted, and the resistance is obtained by the application of Joule's Law, the rate of loss of heat being known.

This method avoids the difficulties of polarisation and transition resistance. The results already obtained agree roughly with Kohlrausch's determinations. A full series of experiments will be made, and the results will be communicated to the Society.

8. Notice of the Recent Earthquake in Scotland, with Observations on those since 1882. By Charles A. Stevenson, B.Sc., Assoc. M. Inst. C.E. (Plate V.)

In 1880 a rather sharp shock of earthquake was felt in Scotland, an account of which I communicated to this Society. Since then seven shocks have been felt in Scotland, and a notice of them, especially of the last, which occurred this year, will, I hope, be of interest to the Society.

On 8th April 1882, the lightkeepers at Phladda Island reported that "at 7.37 P.M. a sudden shock of an earthquake passed the island from west to east, approaching with wave-like motion, dying away with a noise like distant thunder, lasting about three seconds. It was felt in the neighbouring islands."

It may be mentioned that Phladda lies nearly on the line of the great fracture which runs through Scotland from Inverness in a south-westerly direction. This was the third earthquake felt at this station within five years.

On 18th June 1885 a slight shock was experienced at Ballachulish, and also in Glencoe.

On 26th September 1885, at 10 P.M., the lightkeepers at North Unst, which also lies nearly on the line of fracture, reported that "we felt the tower shake very suddenly; the men in bed, as well as the man on watch, felt it the same. We can't account for it, unless it was a slight shock of an earthquake; no heavy sea, and the wind light from north. Barometer, 29·75; thermometer, 46° F."

On 18th December 1887, between five and six in the evening, a very slight shock of earthquake was felt in the Loch Broom district of Ross-shire.

On 12th January 1888 the meteorological observer at Glenquoich, Inverness-shire, observed a mild shock of earthquake.

On Tuesday, 31st January of this year, an earthquake was reported in the newspapers as being felt in the midland counties of England.

Earthquakes of 2nd February 1888.

At 3.30 A.M., 2nd February, a slight shock was felt at Comrie, in Scotland, and about the same hour a slight tremor was felt at Loch Broom. About 5 A.M. on the same day a rather sharp shock of earthquake was experienced along the line of the Great Glen, making itself felt over a large portion of Scotland. The rupture seems to have taken place at Loch Ness, and the shock was propagated in all directions, but with diminishing severity. The following account, kindly communicated to me by Mr Paterson, Engineer to the Highland Railway Company, is of special interest and value, coming as it does from an accurate observer:—

"As regards the actual time the earthquake occurred, one of my assistants fixed it at 5 A.M. exactly, and others at 5.2 A.M. There were the usual six of us, including my daughter, aged 13, and two servant girls under my roof that night. Four of us were awakened by the shock; my daughter and one of the servant girls were not. On awaking I felt a tremor, considerably exceeding the vibration we are accustomed to from shunting operations at the station (we are

on the Crown Terrace, and the engine-shed and station yard are immediately below us), and a creaking of the house timbers, similar to that of a vessel in the trough of the sea, and then a distinct upheaval for from one to two seconds. On collecting myself, I sprung out of bed, turned on our lowered gas, and found that the time by my watch—which was exactly to Greenwich time at 9 A.M. on the previous morning—was 5.2. I have, therefore, concluded that the shock occurred at 5.1 A.M. I can come no nearer to it than that."

The Inverness High Church clock is reported to have been stopped by the shock, but this is very doubtful.

The following reports from lightkeepers who were on watch at the time the shock occurred, and consequently under favourable circumstances for observing such phenomena, will be of interest :—

Tarbetness.—"At 15 minutes to 5 A.M. (sun time), while I was on watch in the lightroom, all of a sudden the tower shook very much—so much that the shades and lamp glasses rattled a good deal. The sensation I felt at the time appeared to me something like being on a railway bridge and heavy waggons passing over it. The vibration of the tower continued, as far as I could judge, for three or four seconds. I could not say I heard any noise before or during the shock. It was blowing fresh at the time, and when such is the case our dome and lantern make a good deal of noise." Barom., 29·69.

Chanonry.—The lightkeeper writes—"The only sensation I felt was a quick motion of the tower, and the chair I was sitting on shook very much. This occurred at 4.30 A.M. on the 2nd, and lasted for four seconds. I heard no noise, neither was it felt in the dwelling-houses." Barom., 29·85.

Corran.—The lightkeeper says—"I was awakened by a strange rumbling sound, and simultaneously came a rude shaking of the dwelling-house to the very foundations, as if caused by a very weighty machine passing. The keeper who was on watch in the lightroom at the time, said he heard a sound as if a flock of wild birds passed the lantern, and almost immediately the whole tower shook so that the spare lamp glasses in the tray and some of the red panes, &c. rattled, but nothing was broken or displaced." Barom., 29·93.

Oronsay.—The lightkeeper says that "at 4.41 A.M. (by our time),

we felt a shock of earthquake, which lasted about ten seconds, accompanied by a dull, heavy rumbling sound. I came off watch at 4 A.M., and was in bed at the time of the shock, but not asleep, and I felt the bed, as it were, bodily lifted from the ground, and some of my children were awakened out of their sleep by the sound. The lightkeeper in the tower felt himself going backwards and forwards on the chair on which he was sitting." Barom., 29·86.

Ardnamurchan.—The lightkeeper writes as follows :—"I was on watch in the lightroom when the earthquake occurred. I first heard a noise as if some heavy weight had fallen, but no shock, and in about one minute afterwards a similar sound, but much louder, with a distinct upheaval but no oscillatory movement. It occurred at 4.40 A.M. (dial time, 5.5 Greenwich). The whole time it lasted did not occupy more than three or four seconds. The lightkeeper, who had retired to rest at four o'clock, had not been asleep. He and his wife heard a low rumbling noise, as if of distant thunder, but no perceptible movement. The noise was not so loud as to awaken any of the others at the station who were asleep." Barom., 29·73.

Lismore.—The lightkeeper on watch "distinctly felt and heard the noise of the earthquake. It began at 4.45 A.M., and continued one and a half minute. The noise was pretty loud, and awakened all the inmates at the station." Barom., 29·91.

This earthquake took place in the month of February, thus adding one more to the already long list of British earthquakes happening during the winter months—from November to the beginning of February. The diagram of British earthquakes, fig. 1, for the last eight years is sufficient to show this tendency. The shock occurred during cold, wet, and stormy weather, the average rainfall for January from five stations on the line of the Great Glen being 4·27 inches, the previous summer and spring having been unusually dry. The barometer was falling very uniformly over the whole of Scotland at the rate of $\frac{1}{4}$ inch in twelve hours. There was no steep barometric gradient. In the vicinity of the Great Glen the average height of the barometer for eleven stations was 29·7. The thermometer was falling over Scotland, the average at 9 P.M. on the previous evening being 32°, and at 9 A.M. on the 2nd 39° F. The moon at the time was in perigee; it was nearly on the meridian, and the earthquake occurred shortly (five days) after full moon.

The area over which it was felt is shown on the accompanying map, Plate V., and measures about 15,000 square miles.

At Inverness, Ardnamurchan, and Oronsay the shock seems to have been distinctly of a vertical character, and at many places an undulatory motion was experienced, the direction in most cases being stated to have been roughly at right angles to the line of the Great Glen. Two or more waves in quick succession are reported from Kyleakin, Grantown, Fort Augustus, Dufftown, Strathpeffer, Perth, Oban, and Falkirk; but at Dalwhinnie a shock is reported one and

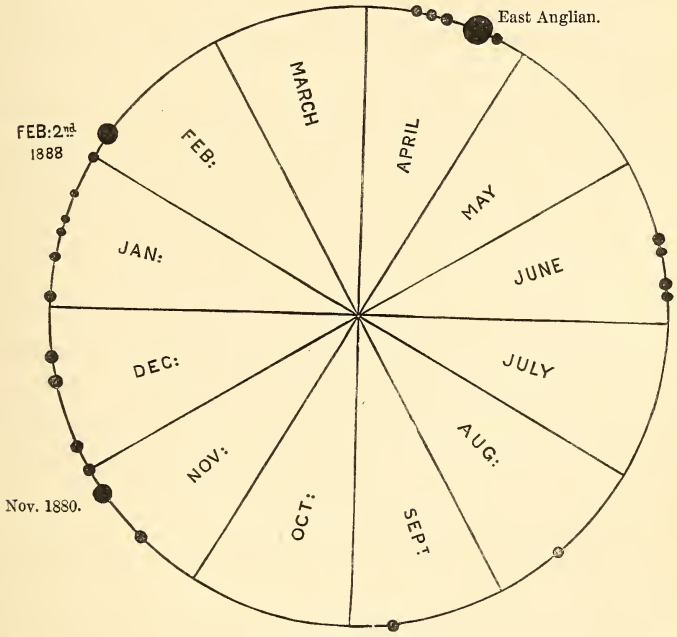

Fig. 1.

a half minute after the first. The duration of the shock at Inverness seems to have been at least two seconds, the average of all observations at a greater distance from the centre of disturbance being about four seconds.

The earthquake was in all probability due to a rupture of the crust of the earth or slip of the strata in the Great Glen, probably of some length, at or near Loch Ness at about 5.1, Greenwich time, and seems to have spread out at a speed of about fourteen miles per minute (which is the average in seven directions); although this is

only approximate, owing to the want of accurate observations at a considerable distance from the source. It reached Inverness at 5.1, Fort William and Glenluichart at 5.3, Oronsay 5.4, Cults, Broadford, Ardnamurchan at 5.5, and Banff at 5.9.

The case of the two shocks one and a half minute apart at Dalwhinnie would lead to the supposition that there had been an overlapping of two earthquake waves here, and the times south of this would appear to point to this having been the case, namely, Ballinluig 5.1 to 5.2, Edinburgh 5.2. It is probable, therefore, that there was a subsidiary rupture, perhaps near Comrie, *not* caused by the passage of the wave from Loch Ness, but nearly simultaneously with it.

The main shock, which was originated in the metamorphosed Lower Silurian rocks, made itself felt over Scotland, regardless, apparently, of configuration or geological formation, except, perhaps, that it was not propagated so far to the N.W. over the Laurentian and Cambrian formations of the north-west of Scotland.

One marked difference between this earthquake and that of 1880 was, that in 1880 the rumbling noise was confined to a very limited area near the source, whereas, in this case, all places, no matter how far distant, heard the sound. Tarbetness and Chanonry lighthouses and Falkirk are the only three places at which "no noise" was reported. Chanonry is on a gravel spit, and Tarbetness is founded on a rock, with 10 feet of gravel over it.

Mr Omond informs me that the earthquake was not felt on Ben Nevis.

In conclusion, I have to thank Mr Murdoch Paterson, C.E.; Mr C. Livingstone, Fort William; Mrs Fowler; Miss Sherriff; Dr Buchan; Rev. Mr Hall, Comrie; Mr W. Anderson Smith, and many others, who gave valuable information.

The information received from various places is given in the accompanying table:—

[TABLE

Stations.	Character of Sound.	Character of Disturbance.	Duration of Disturbance.	Direction in which Wave appeared to travel.
Loch Broom.	...	Shaking, tremor, and creaking of house timbers, and then distinct upheaval for from 1 to 2 seconds.		
Inverness.	Rumbling.	...	1 to 2 secs.	N.W. to S.E.
Dollar.	Rumbling.			
Tarbetness.	No noise.	Shaking.	3 or 4 secs.	
Chanonry.	No noise.	Quick shaking.	4 secs.	
Corran.	Rumbling (preceding).	Rumbling and then shaking.		
Oronsay.	Rumbling (accompanying).	Up and down, and backwards and forwards.	10 secs.	
Ardnamurchan.	Rumbling.	Distinct upheaval, but no oscillatory movement.	3 or 4 secs.	
Edinburgh.	Rumbling.			
Golspie.	Shaking up? down?			
Sound of Mull.	Rumbling (accompanying)	Shaking.	12 to 15 secs.	
Tobermory.	Rumbling (preceding).			
Cromarty.	...	Trembling.		
Kyleakin.	Rumbling noise (accompanying).	Shaking, two waves up and down.	4 secs.	W. to E.
Dalmally.	Rumbling noise.			
Macduff.	Rumbling going west.	Vibration.	1 min.	
Torridon.	Noise.	...	1 to 2 secs.	From W. or S.W.
Glenmoriston.	Rumbling (preceding).	Oscillation.	5 secs.	
Corrymony.	,,	...	10 secs.	E. to W.
Glen Urquhart.	Rumbling (following).	Tremor.	4 or 5 secs.	S.W. to N.E.
Strath Glass.	Rumbling (preceding).	Shake.	4 or 5 secs.	N.W. to S.E.
Eskadale, Strath Glass.	Rumbling (preceded and followed tremor).	Tremor.	Over $\frac{1}{2}$ a min.	
Strath Errick.	Noise.	Trembling.		
Dornoch.	Rumbling (accompanying and followed).	Tremor and jolting; two irregular upward and one side movement.	3 or 4 secs.	S.W. to N.E.

TABLE—*continued.*

Stations.	Character of Sound.	Character of Disturbance.	Duration of Disturbance.	Direction in which Wave appeared to travel.
Clashmore.	Noise.	...	4 to 6 secs.	
Loch Buie.	Rumbling.	...	..	Easterly.
Lismore.	Noise.	...	1½ mins.	
Dalnaspidal.	Rumbling.			
Spean Bridge.				
Oban.	Rumbling before	Wave motion, 3 or 4 waves.	...	From N.E.
Fort-William.	Noise.	Shaking (4 or 5 undulations).	1 min.	N.E. to S.W.
Grantown.	Rumbling (preceded).	Tremor.	1 min.	W. to E.
Dingwall.	...	Oscillation.	10 secs.	
Comrie and Crieff.	Rumbling.			
Banff.	Noise.			
Aberlour.	...	Shake.		
Dufftown.	...	3 vibrations.		
Duthil and Dulnain	Rumbling.	Shake.	...	From W.
Invergarry, Glen Garry, and Glen Quoich.	Rumbling.	Shake.	4 secs.	W. to E.
Strath Nairn.	Rumbling (following).	Shake.		
Tain.	Rumbling (preceding).	Undulation.	8 secs.	W. to E.
Plockton (Rossshire).	...	Shaking.		
Fort-Augustus.	Rumbling.	3 distinct waves with tremors.	2 or 3 secs.	
Keiss.	...	Vibrations.		
Lochluichart.	Noise.	Shake.	...	S.W. to N.E.
Nairn.	Noise (preceded and accompanied).	...	2 to 4 secs. 20 secs.	N.W. S.W. to N.E.
Garve.	Noise.	Tremor.		
Perth.	...	5 or 6 waves.	...	W. to E.
Breadalbane, Aberfeldy, Grantully.	Rumbling (preceding).	...	6 secs.	
Beauly.	Rumbling.	...	...	W. to E.
Strathpeffer.	...	3 distinct shocks	15 secs.	
Glen Nevis.	...	...	...	N.E. to S.W. (?)
Cults (Aberdeen).	...	...	3 to 4 secs.	N. to S.
Dollar.	Rumbling (preceding).			
Falkirk.	No noise.	4 shocks.		
Inveraray.	Rumbling noise.	Vibration.		

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